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Sensory assessment and consumer acceptability of confectionery products made with pine cones

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Abstract. The non-timber part of the forest includes mushrooms, berries, cones, shoots etc. The aim of this study was to evaluate consumer acceptability of confectionery products made with pine cones. For the study two pine cone syrups using osmosis were prepared: pine cone syrup with white sugar (PSW) and pine cone syrup with brown sugar (PSB). Four jams were prepared: apple - pine cone jam without added sugar (AC), pine cone jam with white sugar (CW), pine cone jam with brown sugar (CB), and pine cone jam with stevia (CS). Also, four gummy candies were prepared using different thickeners - gelatine (CG), pectin HM (CpHM), pectin LM (CpLM), and agar - agar (CA). To all products sensory evaluation was performed. In total 23 participants participated in this study. The results showed that the PSW had the most intense colour, aroma, taste, and aftertaste, the sweetness in both syrups was the same. The obtained data for jams showed that the CB and AC was the most pleasant in terms of colour, while the CB and CS was the most pleasant in terms of consistency. For the gummy candies' colour and texture, the highest rated were CpHM. However, for the aroma, taste and aftertaste, the highest acceptance was found in CG. In conclusion, healthier confectionery products with reduced sugar content can be effectively developed by using a non-timber forest resource such as pine cones. This approach allows manufacturers to create confectionary products that satisfy consumer demand for enjoyable sweetness while addressing health concerns.

Key words: gummy candies, intensity test, jams, JAR test, stevia.

INTRODUCTION

Nowadays, people care about a healthy diet, and natural foods are in demand. Natural foods contain many nutrients and are considered 'healthy' (Nabi et al., 2023). The terms 'natural' and 'healthy' are among the most commonly used terms in food marketing. Traditional foods have increased their sales by labeling with the words natural and healthy (Asioli et al., 2017). Sugar is mainly used in food as a sweetener and preservative, and in syrups and jams, it is used to improve viscosity (White, 2018). Sugar is also needed in gummy candies, where pectin is added as a thickener. Gummy candies with lower sugar content can be made if agar-agar or gelatin is used instead of pectin (Vojvodič Cebins et al., 2024). White sugar, which contains 99% sucrose, is used in confectionery, while brown cane sugar contains only 88–93% sucrose, depending on where the sugar cane is grown. Brown sugar is often considered healthier than white sugar. The molasses in brown sugar can affect and alter the taste and aroma of the product (Azlan et al., 2020). Low- calorie sweeteners can be considered as a substitute for sugar. Low - calorie sweeteners allow consumers to choose foods and beverages with different calorie content and sweetness. Sweeteners such as acesulfame K, aspartame and stevia are 50 to 600 times sweeter than sucrose, while neotame is 7,000 to 13,000 times sweeter than sucrose. Stevia (*Stevia rebaudiana (Bert.)*) is a natural sweetener, and due to its origin, it is considered the safest sweetener (Abdullah et al., 2014). With the growing interest in the use of sweeteners in fruit products, such as jams, concerns about changes in taste and texture are growing. Consumers are aware of sugar reduction and substitution, but there is a lack of understanding of how the taste and texture of jams change. Jam is a food product obtained mainly by boiling fruit pulp with sugar, sometimes also adding pectin, citric acid, and preservatives (Uribe-Wandurraga et al., 2021). In jams, sugar can be replaced with a sweetener - stevia. Stevia is resistant to acid and heat, so it is a good alternative to sugar (Nourmohammadi et al., 2021). Trees of the genus *Pinus* are among the most widespread trees in the world. Pines are used for their wood, resin, and nuts, while needles are mainly processed into extracts due to their high antioxidant activity and bioactive compounds (Xu et al., 2012). Pine cones, like other coniferous products, are rich in phenolic acids and flavonoids, which have beneficial effects, as well as antioxidant properties (Ferreira-Santos et al., 2020). In some parts of Asia, pine needles, cones, and pine pollen are used in food and as dietary supplements. Traditionally, syrups and tea were made from pine cones, but today their use can be expanded to e.g. in jams, desserts, etc. (Karklina & Ozola, 2023a). In Latvia, the use of stevia in food is in accordance with EU Regulation 2021/1156, in which stevia is indicated as stevia glycoside and designated as E960a. Stevia glycoside can be used in jams, gummy candies, chapter 04.2.5.2 of the regulation describes their use. The maximum permitted amount is indicated as 200 mg kg^{-1} (Commission Regulation (EU) 2021/11515). However, the Latvian Food and Veterinary Service (PVD) monitors food safety and regulation in Latvia. According to the PVD, if a product does not contain pine cone pieces, then the product is classified as a food, but if it contains pine cone pieces, it is classified as a food supplement, taking into account the health benefits of pine cones (MK No. 2015/685). Adding pine cones to products increases the value of the product itself. According to the regulations of the Cabinet of Ministers No. 2015/685, pine cones have health benefits that can positively affect human health. The aim of this study was to evaluate consumer acceptability of confectionery products with reduced sugar content made with pine cones.

MATERIALS AND METHODS

The research was carried out in the laboratories of the Food Institute at the Latvia University of Life Science and Technologies for the development of pine cone confectionery products: syrups, jams and gummy candies. Green pine cones harvested from Scots pine (*Pinus sylvestris*) were used to prepare the confectionery. The pine cones were harvested in a private forest area near Riga, Latvia in June 2022. The green pine cones were stored in high-density polyethylene (HDPE) plastic bags in a freezer at -20 ± 2 °C until further use.

The syrup is prepared using:

- white sugar Dansukker 'Jelgavas cukurs' producer A/S Nordic sugar (Sweden), country of origin Lithuania;
- brown sugar Dansukker 'Demerara', producer A/S Nordic sugar (Sweden), country of origin Malawi.

For pine cone jams used:

- white and brown sugar mentioned before);
- LM pectin with calcium salts 'Sosa', producer Sosa (Spain);
- sweetener Alvo stevia, producer UAB Pajuva (Lithuania).

For preparation of gummy candies used:

- pine cone pieces remaining after syrup preparation;
- LM pectin (mentioned before);
- citrus HM pectin for jelly moulds 'Sosa', producer Sosa (Spain);
- edible gelatin 'Rimi', country of origin Lithuania;
- agar - agar produced in Italy;
- spruce sprout juice, produced by slow rotation juicer sprouts of *Norway Karst L* according to (Karklina, Ozola, Ibrahim, 2024; Karklina, 2024) method;
- and pine cone syrup with brown sugar were also used, based on pectin recommendations (Sosa pectins) and physical parameters of pine cone syrups according to (Karklina & Ozola, 2023a).

The methods for the preparation of each product are detailed below.

Preperation of pine cone syrups

Pine cone syrups were prepared by osmosis according to the method of (Karklina & Ozola, 2023a). The prepared syrups were stored in glass jars at room temperature of 20 ± 2 °C until further use. The prepared syrups were represented in Fig. 1.

Pine cone syrups did not contain pieces of pine cones. Pine cone pieces as a by-product were frozen and used for gummy candy preparation.

Figure 1. Prepared pine cone syrups. Pine cone syrup with white sugar (PSW) and pine cone syrup with brown sugar (PSB).

Preparation of pine cone jams

Regardless of the method of preparation of pine cone jam, the cones were initially blanched for 5 minutes at 80 °C. Blanching is necessary to soften the pine cones. Unprocessed pine cones can be fibrous. Blanching helps to release resin-forming compounds, thus improving the taste of the jam (Boutenko, 2013). Pine cone jams were prepared according to the method of (Karklina & Ozola, 2023b). The materials used and the amounts of jam are indicated in Table 1, all prepared pine cone jams were stored at a room temperature of 20 ± 2 °C until further use. Prepared jams represented in Fig. 2.

Figure 2. Prepared pine cone jams. Pine cone apple jam without added sugar (AC), pine cone jam with brown sugar (CB), pine cone jam with white sugar (CW), and pine cone jam with stevia (CS).

Table 1. Ingredients used for pine cone jam are listed in g per 100 g volume

Pine cone jam type	Pine cones	Water	Apple juice	White sugar	Brown sugar	Stevia	Pectin
Pine cone apple jam	10.0	-	90.0	-	-	-	-
Pine cone jam with brown sugar	10.0	45.0	-	-	45.0	-	-
Pine cone jam with white sugar	10.0	45.0	-	45.0	-	-	-
Pine cone jam with stevia	10.0	45.0	-	-	-	2.0	2.0

Preparation of pine cone - apple jam (AC), used quantities of ingredients mentioned in Table 1

After blanching, the green pine cones were chopped into smaller pieces and boiled in apple juice for two hours until a smooth, flowing mass was formed. The resulting mass was poured into clean, sterilized 250 g glass jars and sealed. The filled jars were stored for further analysis.

Preparation of pine cone jam with brown (CB) and white sugar (CW), used quantities of ingredients mentioned in Table 1

In jams made with sugar, pectin was not added because sugar is able to create the necessary jelly-like consistency for the jam. According to (Garcia- Garcia et al., 2018), pine cones also contain pectin, but their concentration is significantly smaller compared to apples. The process begins in the same way as making pine cone-apple jam. The pine cones are first blanched and then cut into smaller pieces. The pine cones are boiled in water for an hour. Then sugar (brown or white) is added and the mixture is kept on a hot stove until the sugar dissolves, forming a smooth, flowing mass. The resulting mass is then poured into clean, sterilized 250 g glass jars and sealed. The filled jars are stored until further analysis.

Preparation of pine cone jam with stevia (CS), used quantities of ingredients mentioned in Table 1

LM pectin was used to make stevia jam. According to the pectin specification (Sosa pectin's), LM pectin is more suitable for low-sugar and sugar-free jams because it works synergistic with calcium, unlike HM pectin, which relies on high sugar content to form a gel. The water and pine cones were boiled for an hour. Then the stevia and LM pectin were mixed and added to the water and pine cone mixture. The mixture was kept on a hot stove and stirred until the stevia and pectin dissolved, obtaining a smooth, flowing consistency. The resulting mass was then poured into clean, sterilized 250 g glass jars and sealed. The filled jars are stored until further analysis.

Preparation of pine cone gummy candies

Certain volatile compounds that give a more resinous pine aroma are more intense in pine cone syrup than in spruce sprout juice. Therefore, no spruce sprout juice was added to the candies in which pine cone syrup was added (Karklina & Ozola, 2023a; Karklina, 2024) (see Results and Discussion section Fig. 7, B).

Method with gelatin

To prepare pine cone candies with gelatin (CG), the ingredients listed in Table 2 were used. Water was mixed with sugar, pine cone pieces, spruce sap, gelatin, and citric acid. The gelatin mixture was allowed to ripen for 10 minutes. Once the gelatin had ripened, the mixture was stirred and heated to 100 °C. The finished mixture was then poured into molds and left to harden at room temperature of 20 ± 2 °C for 12 hours (h). The prepared gummy candies were stored in polyethylene (PE) bags in the refrigerator until further use.

Table 2. Ingredients used for pine cone gummy candies are listed in g per 100 g volume

Gummy candy	Drinking water	White sugar	Pine cone piecies	Pine cone syrup	Spruce sprout juice	HM pectin	LM pectin	Citric acid	Gelatine	Agar-agar
Gummy candy with gelatine	53.0	20.0	10.0	-	2.0	-	-	1.0	4.0	-
Gummy candy with HM pectin	18.0	18.0	10.0	40.0	-	3.0	-	1.0	-	-
Gummy candy with LM Pectin	30.0	35.0	10.0	19.0	-	-	1.0	1.0	-	-
Gummy candy with agar - agar	45.0	26.0	10.0	-	2.0	-	-	-	-	2.0

Method with HM pectin

To prepare pine cone candies using HM pectin, the ingredients listed in Table 2 were used. The liquid and dry ingredients were weighed separately. The pectin, citric acid and sugar were mixed together and then added to the cold liquid mixture. The product was stirred and gradually heated until it reached boiling point over low heat. Pine cone syrup and pine cone pieces were added during boiling and the mixture was kept boiling for another 10 minutes. The finished mixture was then poured into molds and left to harden at room temperature of 20 ± 2 °C for 12 h. The prepared gummy candies were then stored in polyethylene (PE) bags in the refrigerator until further use.

Method with LM pectin

To prepare pine cone candies using LM pectin with calcium salts (CpLM), the ingredients listed in Table 2 were used. First, the liquid and dry ingredients were weighed separately. The dry ingredient mixture was added to the liquid mixture. The mixture was allowed to swell for 5 minutes and then the combined mixture was heated over low heat, stirring continuously, until it boiled. Continue to boil for 5 minutes. The finished mixture was then quickly poured into molds and allowed to set at room temperature of 20 ± 2 °C for 12 h. After setting, store the gummy candies in polyethylene (PE) bags in the refrigerator until ready to use.

Method with agar - agar

To prepare pine cone candies using agar-agar, the ingredients used are listed in Table 2. The liquid and dry ingredients are mixed separately. The dry ingredient mixture is added to the liquid mixture. The mass was stirred and boiled for 5 minutes at 100 °C. The finished mass was poured into molds and left to harden at room temperature of 20 ± 2 °C for 12 h. After hardening, the gummy candies were stored in polyethylene (PE) bags in the refrigerator until further analysis.

Sensory evaluation of pine cones of confectionery products

Products made using pine cones are specific products with a special taste and smell, so a different evaluation method was chosen for each product. The method was chosen to determine consumer acceptance, for example, an intensity scale test to determine the intensity of the syrup properties (color, sweetness, pine aroma) and to explain in the comments which of the samples they found more acceptable based on the intensity. An arrangement test, in which the jams had to be arranged in order of liking based on different jam properties. And the Just About Right (JAR) test to conclude, by the acceptability, which characteristic seems just about right. All prepared pine cone confectionery products were evaluated using sensory analysis. A total of 23 trained panelists, 22 women and 1 man, all aged 20–22 years, participated. They were students from the Food Institute of the Faculty of Agriculture and Food Technology of the Latvian University of Life Sciences and Technology. The methods used for the sensory evaluation of each product are described in more detail below. The sensory evaluation of pine cone syrups was evaluated according to (Majore & Ciprivіča, 2023; Karklina & Kampsue, 2021) with minor modifications. Participants were asked to evaluate the color intensity, aroma, sweetness, pine flavor, and aftertaste. Example of intensity scale, represented in Fig. 3.

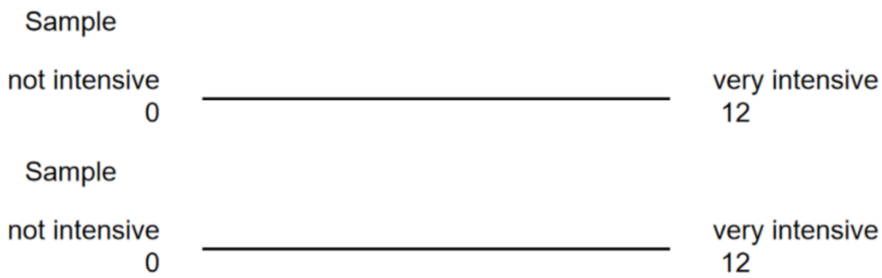

Figure 3. Authors example of a linear intensity scale according to the standard method (DLG, 2010).

A 12 cm Intensity scale was used, where 0 could be described as not intense and 12 as very intense. After the sensory evaluation, consumers were given the opportunity to comment on why the product seemed more acceptable in terms of intensity. The comments were taken into account.

The sensory evaluation of pine cone jams was assessed according to ISO 8589:2007. Participants were asked to rank the jam samples (Fig. 4) from 1 to 4 (1 – least acceptable; 4 – most acceptable) according to their color, taste and consistency.

Properties	Pine cone jams			
	AC	CB	CW	CS
Colour				
Consistency				
Taste				

Figure 4. Authors made an example of pine cone jam arrangement test according to the standard method (ISO 8589:2007).

After the sensory evaluation, consumers were asked to comment on which aspects of the product they accepted based on specific characteristics. Their comments were taken into account.

The sensory evaluation of pine cone candies was carried out according to (Karklina & Ozola, 2024b). Participants rated the gummy candies using the Just About Right (JAR) test, assessing their appearance, aroma, texture and aftertaste. Each parameter was rated as follows: –1 for too little, 0 for almost right and 1 for too much. After this evaluation, consumers were asked to comment on which product they found most acceptable. These comments were also considered.

Statistical analysis

The sensory evaluation aimed to compare the intensity of pine cone syrups, the acceptance of pine cone jam by arrangement test, and the Just About Right (JAR) test for pine cone gummy candies. The pine cone syrups' mean was calculated using WPS Office 2023. A two-way factorial *ANOVA* was also performed on the results to detect significant differences at a significance level of ($p \leq 0.05$). The mean was calculated for the pine cone jam acceptance test, and the data were presented as percentages. The JAR test for pine cone gummy candies was conducted, and the results are also displayed as percentages. WPS Office 2023 was used to present the results for both the pine cone jam and pine cone gummy candies.

RESULTS AND DISCUSSION

Sensory evaluations were conducted for all three groups of pine cone confectionery. The linear scale is a widely accepted method for assessing the intensity of sensory evaluation (Gomide et al., 2021). In the case of pine cone syrups (see Fig. 5), a 12 cm intensity scale was used. Participants were asked to rate the intensity of various attributes, including syrup color, aroma, sweetness, pine flavor, and aftertaste.

Color intensity and pine aroma were higher in PSW than in PSB, a significant difference was observed for color intensity ($p \leq 0.04$) and pine aroma ($p \leq 0.02$). It was observed that the color intensity of the syrups was influenced by the type of sugar. White sugar gives the syrup an amber-brown color, providing a milder and sweeter aroma compared to other sugar types (Vicentini-Polette et al., 2019). The added sugar affects not only the color itself, but can also affect the sensory properties of pine cone syrup. White sugar itself does not have a specific aroma, during processing, it is purified, thus acquiring a white color (Zayapor et al., 2021). Therefore, when making syrup from white sugar, the aroma of the product is formed from the added raw material – in this case, pine cones. In contrast, brown sugar gets its characteristic aroma from molasses, which gives it a more aromatic, milder and slightly caramelized taste and aroma (Başar & Boz, 2023).

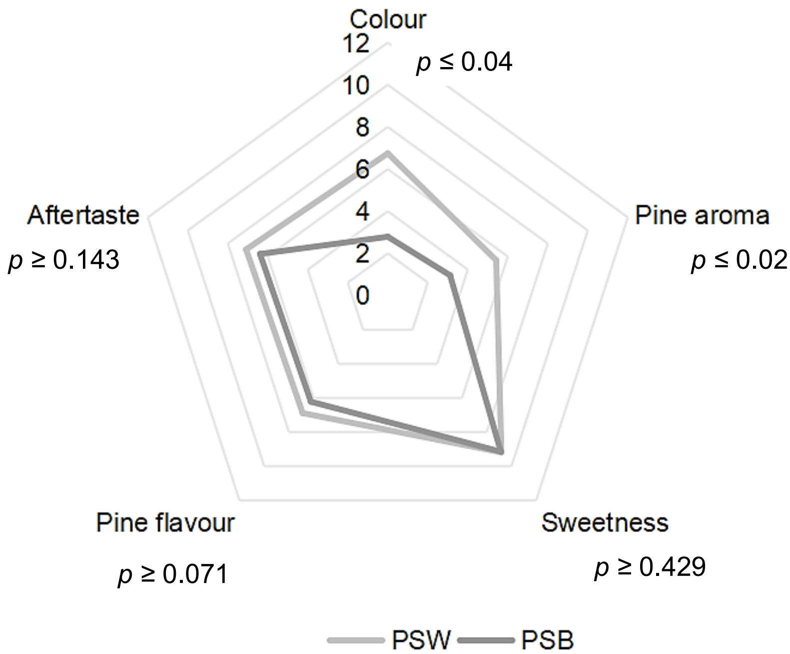

Figure 5. Intensity of pine cone syrups. Pine cone syrup with white sugar (PSW), pine cone syrup with brown sugar (PSB). A significant differences between samples ($p \leq 0.05$) are represented in Fig. 5.

The intensity of the aroma in syrups, as well as the intensity of the color, is determined not only by the added sugar, but also by the pine cones themselves. According to (Karklina & Ozola 2023a), the dominant volatile compound in pine cone syrups made with both white (PSW) and brown sugar (PSB) is 3-carene, which contributes to the resinous and lemony aroma. The concentration of 3-carene is higher and more intense in syrups made with white sugar compared to syrups made with brown sugar. For comparison, it was also observed in this study that PSW had a higher pine aroma than PSB. The molasses in brown sugar suppresses the pine/resin aroma, thus making PSW syrup more intense, as it does not contain molasses. The choice of sugar affects not only the color, aroma and taste of the syrups, but also the sweetness. The sweetness of both pine cone syrups was similar, with no significant difference in sweetness observed between the pine cone syrups ($p \geq 0.429$). Despite the differences in the sugars used and their properties, the amount of sugar added was the same and their sweetness results were similar. In general, white sugar contains pure sucrose, making it much sweeter, which is why it is commonly used in various food products (Arvisenet et al., 2019). Brown sugar, on the other hand, contains molasses, resulting in a lower sweetness intensity compared to white sugar. The presence of molasses affects not only the aroma and taste, but also the overall sweetness of the syrup. The molasses in cane sugar not only provides a pleasant, mild caramelized note, but also imparts a deeper and smoother flavor (Zhao et al., 2024). A slightly higher rating for PSW syrup was observed in terms of taste and aftertaste than PSB, no significant difference in terms of pine flavor was observed for pine cone syrups ($p \geq 0.077$), as well as in terms of aftertaste ($p \geq 0.143$). In general, the choice of sugar affects all sensory properties of the product. Regarding pine cone syrups, consumer comments were taken into account. Consumers, regardless of intensity, prefer PSB in terms of color and taste, as well as aftertaste. 15 out of 23 preferred PSB syrup, because the dark color of the syrup is associated with the color of pine cones. However, 7 out of 23 consumers associate the dark colors of the product with something strong and unpleasant. 8 out of 23 consumers liked PSW better precisely because of its golden color, which they also associate more with pine trees themselves.

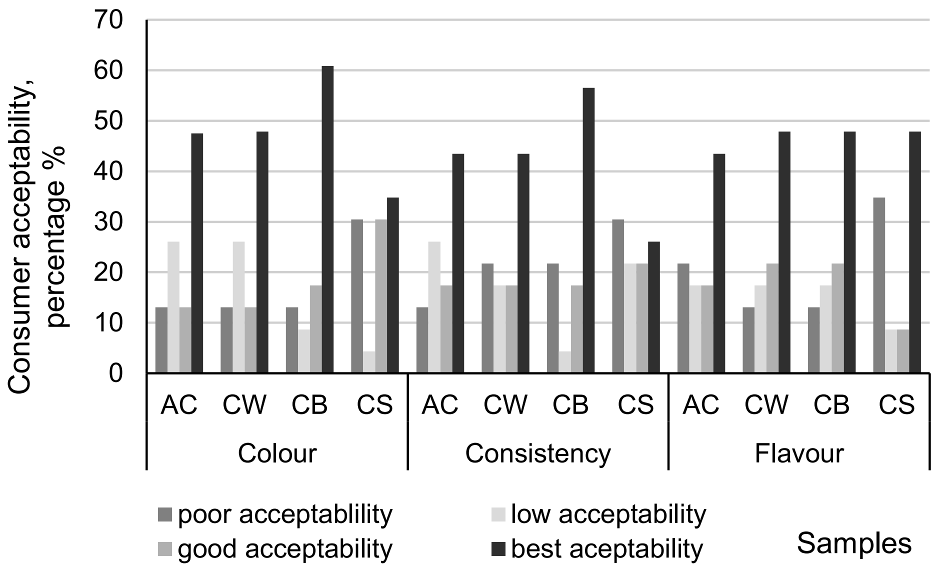

Figure 6. Consumer acceptance of pine cone jams. Apple - pine cone jam without added sugar (AC), pine cone jam with white sugar (CW), pine cone jam with brown sugar (CB), and pine cone jam with stevia (CS).

The arrangement test is used to arrange product samples according to acceptability or liking of the product. The ordering test is usually divided into two types, either the products are arrange from 1 to 4, with 1 being the worst acceptability and 4 being the best acceptability, or vice versa (Yadav et al., 2024). For pine cone jams (Fig. 6), an arrangement test was used in which consumers were required to arrange pine cone jams from 1 with the worst acceptability to 4 with the best acceptability in terms of color, consistency, and taste. When analyzing the arrangement test for pine cone jam, the results obtained indicated that CB 60.86% showed the most favorable results in terms of color. Both jams AC 43.47% and CW 47.82% provided comparable results, while jam

CS 34.78% showed the least desirable color quality. When evaluating the consistency of the jams, CB 56.52% again showed the best acceptability, while AC 43.47% and CW 43.47% of jams showed similar consistency. Conversely, CS 26.08% again received the lowest rating in this category. The taste evaluations did not revealed significant differences between the jams. Pine cone jams CW 47.82%, CB 47.82% and CS 47.82% had the highest taste ratings, which were relatively equal, while jam AC 43.47% received a slightly lower score in this regard. In addition, consumer feedback was systematically analyzed. Overall, participants appreciated the presence of small pine cone pieces in all jams, which contributed to an enhanced taste experience. When comparing jams containing sugar (white and brown sugar), jam CB was noted as having the most positive reviews. However, when it came to jams without added sugar, the most appreciated jam was AC.

Reducing the sugar content in jams affects not only the physical properties (Kārklina & Ozola, 2023b), but also the sensory properties. According to (Gakuru et al., 2019), using sweeter fruits in jam preparation allows for a reduction in the amount of added sugar while maintaining a pleasant sweetness. However, when working with more acidic or sour fruits, it is difficult to add a large amount of sugar to mask their intense taste. However, compared to this study, more sugar is not needed to make the jam more palatable by using more acidic, more intense ingredients, such as pine cones. As consumer comments show, it is possible to make palatable jams without using a large amount of sugar, as was observed with CS and AC jams. In a study conducted by Salgado et al., 2022), different types of added sugars were analyzed, including coconut sugar, brown sugar, white sugar and icing sugar. The results showed that jams made with coconut and brown sugar were darker and more intense in taste, so consumers preferred jams made with white sugar and icing sugar. In this study, participants preferred pine cone jam made with brown sugar to jams made with white sugar or other types. According to a consumer association analysis of consumer comments, brown sugar, the darker color symbolizes pine cones and pine trees more. In addition, a study (Haroon et al., 2024) investigated the sensory parameters of jams with low-calorie sweeteners. The authors tested jams sweetened with stevia, sorbitol, a mixture of stevia and sorbitol, and a control jam made with regular sugar. Overall, sensory attributes were more favorable for jams with added sugar compared to those made with sweeteners. In comparison, this study also observed that pine cone jam with brown sugar had the highest acceptability than jam with stevia.

The Just About Right (JAR) method is widely used in food development to assess consumer preferences and determine optimal feature intensities (Li et al., 2014). When evaluating pine cone candies, the JAR method analyzed several attributes, including appearance, texture, flavor, and aftertaste. Fig. 7, A shows the visual appearance results of the gummy candies. The highest acceptability after the JAR test was observed for pine cone candies CpHM with 78.26%, while pine cone candies CpLM and CA received the lowest scores (26.09). When evaluating consumer comments, they liked the way the cone pieces looked in the candies, but did not like the small nuances in the color, which could be improved by adding more spruce sap in the case of CA candies. Fig. 7, B shows the JAR for consumer acceptance of pine aroma, revealing that pine cone candy CG received the most favorable response with 39.13%, followed by CpHM with 30.43%.

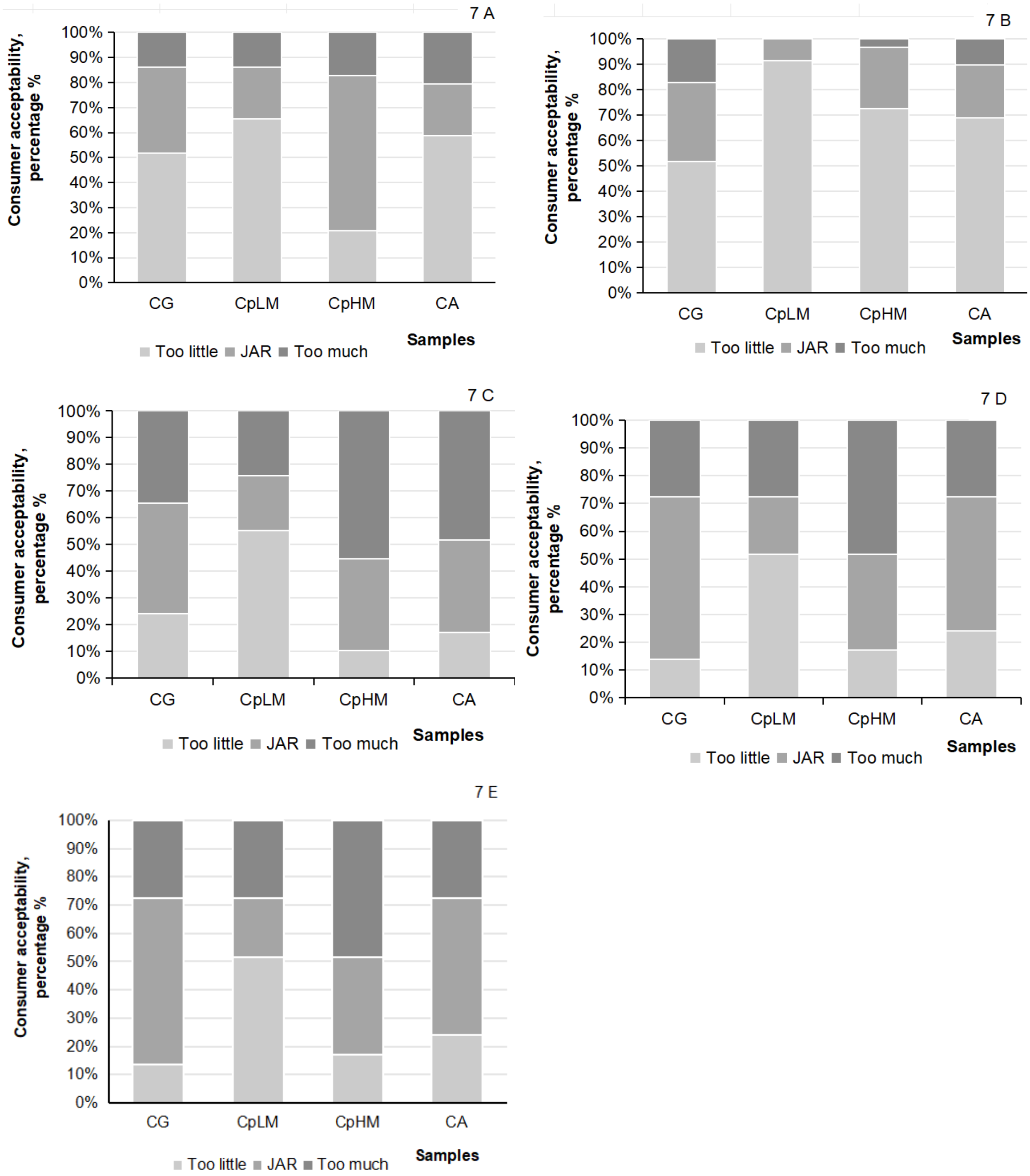

Figure 7. Consumer acceptability of a product features in pine cone candy by Just About Right (JAR) test. Pine cone gummy candy with gelatine (CG), pine cone gummy candy with citrus HM pectin (CpHM), pine cone gummy candy with LM pectin with calcium salts (CpLM), pine cone gummy candy with agar (CA). Appearance of pine cone gummy candies (7, A), aroma of pine cone gummy candies (7, B), structure of pine cone gummy candies (7, C), flavour of pine cone gummy candies (7, D), after-taste of pine cone gummy candies (7, E).

Pine cone candy CpLM received the least favorable rating with 8.60%. The aroma of gummy candy can be influenced not only by pine cones, but also by the thickener used (Pizzoni et al., 2015). Pizzoni et al. (2015), in their study compared the differences in aroma depending on the thickener used using GC-MS (gas chromatography-mass spectrometer) and e-nose (electronic nose). It was concluded that the main reason why thickeners can affect the aroma and flavor of gummy candies is that each thickener has a different effect on flavor release due to its structure and chemical properties, and this effect is further influenced by the candy manufacturing technology, which is also different for each thickener. The aroma and flavour in gummy candies can also be influenced by other added ingredients, such as added pine cone syrup or spruce sprout juice, which in both cases give a resinous flavor, but in varying intensities. In comparison, the predominant volatile compound in pine cone syrup is 3-carene (22.6%), which gives a resinous and lemony aroma. The second compound longifolene (17.0%), which gives a sweet and coconut aroma, and limonene (13.8%) which gives citrus aroma (Karklina & Ozola, 2023a). But in spruce sprout juice, the dominant compound is limonene (37.76%), the second compound is bornyl acetate (21.6%) which gives a pine / resin aroma, while 3-carene is only the 5th most abundant compound at 6.92% (Karklina, 2024).

From this it can be concluded that consumers liked the CG candy with added spruce sprout juice better, because it gives a milder and more pleasant resin aroma and taste than those without spruce sprout juice, although the CpHM candy did not have spruce juice added, so its results seemed good. This could be influenced by the results discussed above when evaluating pine cone syrups. Fig. 7, C shows the JAR for consumer acceptability of texture, CG pine cone candy was again in first place with a JAR score of 52.17%, while both CpHM and CA combined score 43.48%. In a USA study (Ataman, 2023), they concluded that consumers prefer gummy candies that are soft like pectin gummy candies. But in this study, the opposite was observed, with gelatin gummy candies receiving higher votes for the best acceptability than pectin gummy candies. Gummy candies with agar - agar does not require a lot of sugar as it is with pectin and are much more suitable for vegans therefore, its popularity might be greater for use in jelly candies (Tarahi et al., 2023). But the consumers commented that CA texture resembles cartilage rather than candy, so the liking score was not as high as CG candy. However, in terms of taste and aftertaste, CA was rated well. Fig. 7, D shows the JAR for consumer acceptability of the taste, where pine cone gummy candy CG achieved the highest acceptability of 73.91%, while a slight decrease was observed for pine cone gummy candy CA at 60.87%. The lowest ratings for the taste of pine cone gummy candy were observed for CpLM and CpHM, 26.09% and 43.48%, respectively. The difference in taste could be based on the previously discussed aroma that forms the candy. Because aroma and taste are in a sense closely related as in flavour. Pine cone syrup was added to CpLM and CpHM, which was intense in terms of taste, as well as volatile compounds that shape the aroma can influence consumer choices. Finally, Fig. 7, E shows the JAR for consumer acceptability in the aftertaste, which reflects the taste results. Overall, the most significant consumer acceptability was observed for the CpHM and CG variants of pine cone gummy candies. Based on consumer comments, these candies had a more pleasant taste. According to (Vojvodić Cebin et al., 2024) the gelatin and sugar mixture provides a highly rated sensory evaluation of sweetness and chewiness, which was also observed in this study for taste, aftertaste. Pectin in candies requires both sugar and an acidic environment to create a gel-like structure (Gawkowska et al., 2018). In this study, the sugar content was provided by adding pine cone syrup prepared with brown sugar, while the acidic environment was provided by added citric acid, as well as the pine cones themselves. According to (Karklina & Ozola, 2023a), the total soluble solids in pine cone syrups with brown sugar added can range from 61.3 ± 0.83 to 64.3 ± 0.26 °Bx, while the pH is 3.44 ± 0.01 to 3.66 ± 0.02, which is necessary for pectin to function. According to (SOSA Pectin) the manufacturer of HM and LM pectin, the necessary conditions for pectin to work are a pH value of 2.8 to 4.7 and a soluble solids content of at least 60 Bx° and 80 Bx°. In particular, the inclusion of pine cone pieces was generally considered acceptable by respondents, indicating a positive perception of this ingredient in gummy candy formulations. Sweets are considered one of the most popular confectionery products with low nutritional value but high calorie content. Adding more nutritious ingredients or ingredients with higher bioactive compounds could increase the value of gummy candy (Vojvodić Cebin et al., 2024). Adding pine cones to gummy candy can increase the value of gummy candy (Ferreira-Santos et al., 2020).

CONCLUSIONS

Sensory assessment and consumer preferences in general showed a confirming trend towards healthier choices and options for new product development incorporating less traditional ingredients, such as pine cones.

From the assessed pine cone syrups in terms of color, taste and aftertaste consumers preferred sample PBS (pine cone syrup with brown sugar) instead of PSW (pine cone syrup with white sugar) due to a lack of sensory parameter intensity.

For jams, CB (pine cone jam with brown sugar) also showed better results in terms of color and consistency, but in terms of taste, CW (pine cone jam with white sugar), CB and CS (pine cone jam with stevia) showed equally good results.

The evaluated pine cone gummy candies where various product properties where evaluated using JAR test, concluded that pine cone gummy candy with gelatin showed the best results in terms of aroma, structure, taste and aftertaste, but in terms of appearance, the highest results were detected in sample CpHM (pine cone gummy candy with HM pectin).

In conclusion, it is possible to develop confectionery products that incorporate pine cones, and the industry can innovate in ways that meet consumer desires for delicious sweets while addressing current health concerns (reducing sugar). This approach not only satisfies the growing demand for healthier options, but also promotes sustainable sourcing practices, which ultimately benefits both producers and consumers.

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